A Discussion about Small-scale Agriculture

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HYPOTHESIS

The examples provided and the reports quoted in this document reflect a need to distinguish two important elements when discussing agricultural development in developing countries—an understanding of the agronomic factors and a clear definition of the population targeted for intervention. The solutions at the end of this document are provided based on several things: 1) how Feed the Future can have the most positive impact on the most food insecure populations; 2) how Feed the Future can create an environment that has long-term success by building on local and regional resources and 3) how Feed the Future can demonstrate leadership in developing the most appropriate and productive agricultural systems for small-scale farm operations.

I have not addressed how to develop commercial or industrial agriculture for four reasons: 1) commercial agriculture tends to develop on its own with the proper public policies in place; 2) the majority of farmers in Africa are not commercial farmers; 3) the 500 million small-scale farmers in Africa include the majority of the rural population that is food insecure and 4) the evolution of broad industrial agriculture across the continent will take years to develop, involving changes in policy, the expenditure of trillions of dollars in infrastructure and decades of training and capacity development.

"There is no silver bullet—no technology can immediately fix 50 years of neglect."

I have also not addressed the issue of "land grabs," which will have a significant impact on natural resources, community rights and farming practices. This issue is linked to any discussion regarding agricultural development because it will affect government decisions and how local farming is treated. The idea that any investment in agricultural development is a good investment is wrong. Many of the arrangements that have transferred land use to date are contracts that transfer natural resource wealth to foreigners at the expense of poor populations and small-sale farmers—these actions should not be ignored by USAID or other government agencies.

In 1950, the United States was much further advanced in research, infrastructure and production than Africa is today. The U.S. government made rural development and agricultural productivity a priority. This commitment is what provided the basis for significant productivity gains for U.S. farmers over the next 60 years. (United States)

This document focuses on why Africa must be treated differently than traditional large-scale farming systems in terms of creating effective and appropriate processes and techniques that assist small-scale farmers. It is not business as usual because that approach will continue to fail. A large portion of success can be achieved by adopting existing knowledge if it can be brought to scale. The largest challenge is overcoming the current mindset. Solutions do exist that provide a blueprint for USAID to demonstrate bold leadership in addressing food insecurity in Africa.

EXECUTIVE SUMMARY

Historical Context

The United States began the development of its current agricultural system in the late 1700s. The most significant aspect was the establishment of a land tenure system which was the foundation of early success by providing farmers the opportunity to use land as a mechanism to borrow money, create equity and invest in improving production capacity. Generally, over a period of 100 years (1800-1900) the development of rail systems, roads, rural electrification and research created an environment that encouraged innovation and investment for the next 100 years.

Today, agricultural production in the United States is based on an integrated system of high-yield output that utilizes extensive mechanization, high levels of inputs and benefits from years of public and private research and development aimed at intensive monoculture production.

Some of these lessons transfer to Least Developed Countries (LDCs); however, the most successful system for poor, small-scale farmers is likely a system that is designed on low-input and medium-output, or medium-input and medium-output.

"The right to food of many people in some of the poorest countries of the world is at stake. The belief that large-scale plantations (farms) are needed to 'modernize' agriculture is dominant in many governments and investor circles, but there is no evidence to back it up."[1]

Specifically in Africa, large mechanical production systems will not work well in many areas. A commercial farmer (elite), a smallholder farmer with access to local markets (stable) and a subsistence farmer (fragile) requiring a risk-averse livelihood strategy all have different profiles and require different solutions (see page 16).

I began with a description of U.S. agricultural development not because other countries should adopt all our specific development processes but to demonstrate that it took over 200 years of the proper investment and policy to create an environment to address many of the issues in the current debate. In plain English, you cannot shortcut agricultural growth. There is no silver bullet—no technology can immediately fix 50 years of neglect. It is irresponsible to promote solutions that only fit *elite* farmers and expect *fragile* farmers to benefit.

These points were emphasized in a publication by the Food and Agriculture Organization (FAO) of the United Nations and The International Bank for Reconstruction and Development / The World Bank in 2009. "Based on a comprehensive review of the literature, as well as the value chain analysis presented in this report, there is little to suggest that the large-scale farming model is either necessary or even particularly promising for Africa."[2] The question remains, why then is there such a push for a Green Revolution approach in Africa?

Previous Assumptions

There is no question that improved seeds must play a role in a successful strategy to improve output. However, depending solely on the development of improved seeds fails to recognize the difference in available labor, cultures and farmer priorities.

Monoculture cropping systems similar to ones in Asia do not fit well in many African conditions. Poor farmers facing a variety of environmental challenges depend on diversity to survive. In addition, monoculture production is dependent upon good market access and the ability to withstand price shocks; poor populations often lack access to markets and cannot absorb environmental or price shocks—sometimes spending as much as 100 percent of their income on food and still experiencing hunger. (Bangladesh)

Furthermore, there are a number of indigenous crops in Africa that have been grown for the past 6,000 years that contribute to food security, but are largely ignored by Western researchers. According to a report by the National Research Council, "Africa has more native cereals than any other continent. It has its own species of rice, as well as finger millet, fonio, pearl millet, sorghum, tef, guinea millet, and several dozen wild cereals."[3] Because researchers are not as familiar with these crops, they are often ignored while more attention is given to the growth of the world's major grains.[4] Further, these crops do not attract attention because they are not suitable as cash crops and are not in demand to meet export markets.

Poor farmers survive as a result of crop diversity. When crops fail, there are no permanent government safety nets; often the only support is emergency food assistance. The child pictured is severely malnourished and is at an emergency nutrition center as a result of three years of failed crops. This family has lost all of their livestock and are now dependent upon emergency food assistance. The development of monoculture production systems for poor farmers can increase the risk of hunger and malnutrition. (Ethiopia)

Without land ownership you cannot achieve successful agricultural development at scale. This affects production capacity and land use in significant ways. The FAO and The International Bank for Reconstruction and Development / The World Bank report states that "in Thailand, land policies that facilitate land titling and provided tenure security for small-scale farmers, combined with a generally more smallholder-friendly policy environment, allowed small-scale farming to emerge as the dominant mode of production."[5] Therefore, based on this example and the evidence found in the history of the United States, Europe, Brazil, Australia and others, any successful strategy must address land ownership.

"Poor farmers do not farm for profit; they farm for consumption."

Western or Asian-style monoculture farm systems will not be effective with small-scale farmers in Africa; monoculture systems fail to address the critical importance of crop diversity required by poor farmers. The goal of Green Revolution-style systems is to provide the highest output, typically in monoculture conditions; in contrast, small-scale farmers require stable yields while maintaining diversity. Achieving the highest yield is not necessarily a poor farmers' primary goal—general food security, labor requirements and market access are often higher priorities.

These are poor people first; they are farmers by default. Poor farmers do not farm for profit; they farm for consumption. The adoption of technology by small-scale farmers must be driven by a reduction in risk as well as increased yields.

India is often used as an example for African agricultural development; however, it is a poor example. Child malnutrition rates in India remain worse than in many African countries—averaging 42.5 percent in children under five.[6] India is also now experiencing challenges with water depletion and the negative effects of over-fertilization. Therefore, simply increasing food production does not ensure improved nutrition, access or affordability to food or sustainable farming practices. India is a single country, and Africa is a continent comprised of 54 countries. Therefore, the comparison of the two and the generalizations which result lead to misconceptions of how agricultural lessons transfer.

"Each intervention must be site specific, economic specific, culture specific, climate specific and country specific."

Soils in Africa are severely depleted and require rebuilding through biological processes. Healthy soil includes the physical, nutritional, chemical, biological and water aspects of the soil. The condition of these elements will determine the degree to which the soil has been compromised. Microbes and living organisms help to create healthy soil; synthetic inputs alone cannot achieve the same results. The productivity of soil is determined by decomposition rates, nutrient recycling, inherent fertility, acidity, organic matter, cation exchange and carbon levels. All of these affect the soil's ability to respond to environmental stress. Long-term agricultural productivity is dependent on good soil management. (Sierra Leone)

Agriculture is sometimes treated as a science—it is not a science! It uses science, but production agriculture has hundreds of variables that constantly change within each year. Therefore, the focus on technology may not provide the solutions many anticipate.

Africa needs a "Brown Revolution," not a "Green Revolution." Africa has 220 percent greater population and 206 percent more land mass than the United States. It has about 7.4 percent fertile soil across the entire continent; however, the United States has about 30 percent fertile soil.[7] Africa has numerous agro-ecological zones, ranging from arid to tropical; the United States Corn Belt is primarily temperate. The weathered soils of Africa and the diversity in climates provide unique challenges in agricultural production.

Smallholder farmers who comprise 73 percent of the farmers in Africa and farm more than 70 percent of the arable land[8] will need to be part of the equation to achieve food security across the continent. Systems must fit their needs, but these systems have yet to be fully developed. Most of these farms are not suitable for Green Revolution-style development because they are small, fragmented, highly variable pieces of land with poor infrastructure.[9]

Three-quarters of potential agricultural land in Africa is subject to soil and terrain constraints, making large-scale mechanization difficult or uneconomical.[10] Weathered soils in Africa have low inherent fertility and high fragility. Over half of the production zones in Africa have serious fertility problems, and 75 percent of agricultural soils in Africa have been significantly degraded by human activity.[11]

The assumption that the appropriate inputs for poor farmers are similar to those used in countries with significantly higher GDP and income levels is incorrect. Making the poorest farmers reliant upon fossil fuels will worsen climate change and is likely to fail in many places where access, affordability and knowledge of how to utilize inputs are serious impediments. The consistency of supply and quality is also a serious problem across the continent.

Most research has been directed at where financial resources exist, and those resources are not available in remote places with poor, small-scale farmers. This is a primary reason why the majority of the discussion today revolves around pushing our system and knowledge into places where there is poor productivity rather than building systems that fit specific soils, growing conditions, infrastructure, etc.

A significant challenge is the poor quality of data that exists for decision-making. It is difficult to get good soil profiles or hydrology information on our farms in South Africa, and South Africa is far ahead of many other African countries. Without understanding the problems, you cannot find the correct solutions. Better data is critical to success.

Too often Africa is treated as a continent, yet each of the 54 countries in Africa have unique and often very different sets of circumstances affecting production capacity. Each intervention must be site specific, economic specific, culture specific, climate specific and country specific.

The lack of government *will* to make agriculture a priority creates a significant roadblock. The spending threshold of 10 percent of national budgets is still low and continues to be missed as a target by the majority of African countries. The assumption that this will somehow change is a big one, and success cannot be achieved without immediately changing this low level of commitment.

Global Assessments

I will focus on three major groups of information in this section: 1) the 2004 report by the InterAcademy Council commissioned by the United Nations under the direction of Kofi Anan; 2) the 2009 International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) report which was originally initiated in 2002 by the World Bank and the Food and Agricultural Organization of the United Nations and 3) the recent Fourth United Nations Conference on Least Developed Countries.

InterAcademy Council Report

The key information retrieved from this report is the following statement: "The IAC panel concludes that African agriculture will require numerous 'rainbow evolutions' that differ both in nature and extent among many different types of farming systems and institutions throughout Africa—rather than a single Green Revolution."[12]

Access to markets is a barrier to poverty alleviation. If farmers are able to produce a sufficient crop to have surplus amounts for sale, often they cannot reach markets to sell the products and the excess production rots. This is a result of poor infrastructure, limited transportation and poor or no post-harvest storage. (Togo)

The findings that led to this conclusion include: a lack of dominant farming systems, a reliance on rain-fed production, a majority of the continent suffers from weathered soils of poor inherent fertility, key roles of woman are often not considered, a lack of functioning competitive markets, a serious lack of investment in agricultural research and development, a large diversity of farming systems, the importance of livestock, a lack of conducive economic and political environments, low and stagnant labor productivity, minimal mechanization and the predominance of customary land tenure.

The report also states:

> "In contrast to Asia—where irrigated rice-wheat systems predominate and thus where improved rice and wheat varieties could make a major difference—the diverse African situation implies that no single magic 'technological bullet' is available for radically improving African agriculture."[13]

The IAASTD Report

The IAASTD report involved 11 consultations and over 800 participants. The concept behind this report was endorsed as a multi-thematic, multi-spatial, multi-temporal intergovernmental process with multi-stakeholders. The report states:

> "Over the last 60 years, intensive production practices of high-yielding staple food crops were promoted, often on land cleared of much of its natural vegetation."[14]

> "[I]ncreased attention needs to be directed towards new and successful existing approaches to maintain and restore soil fertility and to maintain sustainable production through practices such as low-input resource-conserving technologies based on integrated management systems and an understanding of agroecology and soil science."[15]

> "Organic agriculture (OA) includes both certified and uncertified production systems and encompasses practices that promote environmental quality and ecosystem functionality."[16]

> "The basic principle of OA is to enhance soil organic matter and soil structure through the supply of macro and micronutrients from animal and green manure (compost/mulch), nitrogen-fixing legumes, enhanced cation exchange capacity and nutrient retention."[17] *It is important to differentiate between the terminology of organic and biological. Organic can imply a system as we know it and define it in the United States. Organic would restrict the use of necessary technology; however, the base system should be biologically-based, not driven by synthetic inputs.*

> Reduced tillage and conservation agriculture currently practiced are economical systems that have been widely adopted in the last 25 years in North and South America, with current expansion in South Asia.[18]

> "Some of the benefits of conservation agriculture include reduced wind and water erosion, increased water use efficiency and water infiltration and enhanced conservation of soil organic matter."[19]

Perhaps one of the most important comments from the paper is found under the heading "Challenges." It summarizes the four critical elements to achieving success. It states: "Current assessments indicate that new research investments could improve multifunctional performance significantly and rapidly in all parts of the world. This requires that 1) existing systems of multifunctional merit be up scaled and their underlying principles brought into mainstream practice; 2) empirically tested designs for new approaches and systems be more widely promoted in small-scale and industrial systems; 3) data and information be available in key areas of concern; and 4) policies and institutions that facilitate multifunctional agriculture be strengthened."[20]

Fourth United Nations Conference on Least Developed Countries

The conclusions of this conference were consistent with the identification of poor soil fertility issues and diverse growing conditions found in the IAC report; the conclusions are also consistent with the IAASTD report where it identifies the need to build a biologically-based system using low-input resource conservation-based approaches. It states that the transformation required in Africa should not be based on expensive imported external inputs.

If the changes were based on the high-input, intense production model of industrial agriculture, the conference conclusions state that would put Least Developed Countries (LDCs) in a situation of "extreme vulnerability."

Solutions

The following solutions are all consistent with the two reports and one conference referenced in the previous section. Some of these solutions are very basic and are accepted by many stakeholders. Others are geographically specific which will reflect different ideas and approaches than what some would commonly prescribe.

I begin this section with a quote from the United States National Research Council on lost crops in Africa. It states: "After the Year 2000, it could well be advances in today's 'second tier' cereals that are the buffers against famine. It is they that have the greatest amount of untapped potential…they are the crops of the poorest countries, which means their improvement could directly benefit the people in the greatest need."[21]

Soil Fertility

Improved soil fertility is critical. Existing NPK fertilizers provide crops with water-soluble forms of inorganic chemicals that will provide increased yields on "working soils." However, they provide little to no value in building soil fertility and will have limited or no success on "dead soil." Therefore strategies must include biologically-based systems to rebuild soil fertility.

Slash-and-burn agriculture techniques destroy valuable ecological areas and do little to solve the long-term issues of poor soil fertility. This process also destroys the biomass that can be used to improve soil health. (Rwanda)

When crops are stressed, it is often due to a lack of nutrients or water. Soil is a living ecosystem, when the biological activity is decreased, the soil has less resilience to environmental stress. (Zambia)

This combine will cut about 20 acres of wheat per hour and does not stop—unloading onto an auger wagon as it continues to harvest. (inset) This woman has picked her wheat by hand and is cleaning it by using the wind to separate the chaff from the grain. The combine performs all of the necessary functions to provide a finished, clean grain. (United States, inset: Ghana)

This is more important today because there is less opportunity to leave land fallow. Populations and space pressures are forcing farmers to use land more intensely and to continue to clear land for new crop acreage. Therefore, universities, agricultural ministries, NGOs and other entities that are capable of providing extension services need to provide greater training in biological production systems.

Feed the Future could be the leader in encouraging systems that address the physical shortcomings of the African continent by developing a biological approach to African agriculture at scale. Endorsing such an approach would begin the "Brown Revolution" which Africa must experience.

Second Tier Crops

Feed the Future could support pilot research programs of "second tier" cereal crops, leading to increased yields from these indigenous sources. These crops have never received the level of support or research provided to the basic cash crops that are driven by profit and export markets. USAID could encourage research into these crops and jumpstart this process.

Improved Seeds

It is impossible to achieve the necessary yields to address food insecurity without improved seeds. Therefore, taking into consideration accessibility, affordability and knowledge, open pollinated varieties (OPV) should continue to be considered as viable options. However, where hybrid varieties can be combined with the proper fertility, more progress will be achieved.

As farmers progress, they are able to make different choices. Leaving OPVs out of the equation creates a much larger hurdle for poor farmers. Maximum yield is not always the ultimate goal of a poor farmer; therefore, the solutions for these farmers should not be driven by societies that have different goals; e.g., the goal of large seed companies and farmers in developed farming systems is yield. Different goals require different solutions.

USAID could provide balance to the debate on improved seeds by supporting different levels of seeds for the appropriate level of farmers. Simultaneously USAID should continue to support the development of a strong seed sector using the best technology where appropriate.

Extension and Farmer Field Schools

Extension services are at the heart of the success of United States agriculture. We need to take a trip back in time to understand what this means in Africa. African yields today are similar to the yields in the United States around 1900. The following table puts into perspective the current capacity in Africa; keep in mind Africa is 206 percent greater in land mass than the United States.

A Comparison of U.S. and African Statistics	
United States – 1950s	**Africa - Today**
3.4 million tractors in use[22]	580,393 tractors[29]
25.8 million acres irrigated[23] (this comprised 5.43% of arable land)[24]	33.8 million acres[30] (this comprises 5.55% of arable land)[31]
2.7 million tons of nitrogen used per year[25]	3.4 million tons[32]
97 percent of farms had electricity[26]	Approximately 8 percent[33]
95 percent of corn acres used hybrid seed[27]	Less than 20 percent[34]
1.68 million miles of paved roads[28]	Approx. 107,937 miles (excludes South Africa)[35]

As water becomes more scarce, efficient irrigation methods will become more important. The infrastructure required for efficient irrigation is significant. Without the proper support systems, it will be difficult to expand irrigation. Regardless, in Africa, due to the physical water constraints, the continent will remain predominantly dependent upon rain-fed agriculture. (United States, inset: Mozambique)

These girls haul the equivalent of about a half bushel of shelled corn to a wooden storage shed that is often infested with weevils. It would take one girl about 5,600 trips to carry the load contained in the four wagons on the right which consists of 2,800 bushels (78 US tons) of corn. Each girl travels about one mile in each direction. Under comparable conditions, in order for one of these girls to carry 78 tons of grain, she would have to walk 11,200 miles—the equivalent of almost halfway around the world. (left: Ghana; right: United States)

This boy seeds by hand, this method does not allow for proper seed depth or spacing. The inconsistencies result in varying germination, emergence and pollination, which in turn results in yield loss. In this instance, the seeds have been saved from previous harvests and replanted which severely limits their yield potential. (Ethiopia)

In certain circumstances, yields can be increased by the most basic education. As we strive to achieve uniform emergence in the United States using well developed machinery, many African farmers plant by hand. U.S. farmers spend a significant amount of money to eliminate skips and doubles in their planting; farmers in other parts of the world purposely plant two to four seeds per hole. This is, of course, driven by the concern for adequate germination; however, it has a negative effect on yield. Therefore, training in proper row spacing, accurate seed depth placement, correct and consistent seed spacing, seed density, and timing of crop planting and harvesting offer as much potential as many other interventions.

Therefore, if Feed the Future develops a training program for existing African institutions based on basic agronomy techniques, it would address some of the easiest areas to correct. Currently many of the efforts today want to bypass the basics; therefore, these easy gains are overlooked.

Human and Institutional Capacity

The development of human and institutional capacity is often discussed, but historically funding has been limited. My experience is that private donors are slow to invest in African institutions, including my Foundation. Developing human and institutional capacity in Africa would require large amounts of funding and significant oversight in a system that often lacks integrity. It can take years to see the results. However, USAID could provide the proper resources to have a significant impact in this area. Without it, it is not likely that any successful long-term, well-funded extension service will develop and be maintained.

Conservation-Based Agriculture

A key component to success will be training and equipment that can take conservation-based agricultural production to scale. These techniques are particularly important in dealing with the effects of climate change. This is one area where knowledge transfer could be successful, but it requires intense training. It also helps build soil fertility, contributes to better soil structure, conserves water, can help suppress weeds and acts as a carbon sink. It is particularly helpful in addressing gender issues because the system requires less labor.

USAID could demonstrate leadership by organizing farm equipment manufacturers and identifying equipment that could be tailored for small-scale farmers who are not subsistence farmers and who farm plots which can accommodate limited mechanization. U.S. manufacturers could provide "mechanization packages" at low levels of investment to promote the use of no-till and strip-till. This solution will not apply to all situations.

Conservation agriculture can consist of numerous approaches. Above, the soil is covered with previous crop residue. In contrast, below, the soil has been blown almost like snowdrifts due to excessive tillage. The primary factor with conservation agriculture is maintaining cover over the majority of the soil year-round. This provides many benefits: increased organic matter, improved cation exchange, carbon sequestration, reduced soil erosion, improved water infiltration, weed suppression, reduced compaction and opportunities to increase alternatives to synthetic inputs. (above: United States, below: South Africa)

Primitive tools like this roller crimper (above) and single row planter (below) can be effective on small plots. The challenge is training farmers and developing local or regional manufacturing to provide affordable tools. (above: Mozambique, below: Senegal)

Post-Harvest Losses

The most immediate gains in reducing food insecurity could likely come from reductions in post-harvest losses. Since the labor and financial investment has already been made in the crop, this is an extremely expensive loss. In turn, it is not difficult to see how reducing these losses could have the greatest return. Feed the Future could assemble a team of experts on crop storage and provide recommendations on what solutions work in different growing climates.

Insect damage, mold and other factors can cause significant damage to crops without the proper storage facilities and ancillary drying equipment. The damage in this photo is to the only source of food for a family of seven. As a result, they will face hunger later in the year. (Zambia)

This team could provide information on approaches that have worked in various agro-ecological zones, how to bring them to scale, how to utilize ideas that work in other systems that transfer and suggest how funding should be applied. This will require small infrastructure development at a very local level.

Farmer Cooperatives

My Foundation has seen a significant difference in our level of success in Latin America based on the use of formal farmer cooperatives (co-ops). The advantages consist of a more efficient use of resources, more effective communications, better purchasing power and the establishment of a political base. It is a much more effective way to provide training. We have found that the process of gathering individual farmers together is not the same as the dynamics that result from a co-op. Using a village approach does not provide the same advantages. This is a lesson we have learned over the past decade.

Feed the Future could develop a best practice model for the establishment of co-ops and provide incentives for farmers and governments to develop co-ops. It may require legal assistance, modifications to country laws or advocacy at the government level—all of which USAID could offer.

Storage systems provide opportunities to market crops at more attractive prices as well as providing protection against damage to crops. In the case of small-scale farmers, often the latter is more important. Proper on-farm storage in Africa is almost nonexistent and commercial storage is limited, particularly to larger urban areas where processing is available and export facilities exist. (United States)

Better Leverage Existing Partnerships

Many interventions fail because they do not provide adequate exit strategies. An excellent example of a partnership that can be further leveraged is with the World Food Program (WFP). WFP's Purchase for Progress (P4P) program was initiated at the procurement level. This is the demand side, but ultimately it will be the supply side that determines the success of the P4P concept and the impact it can have on poor farmers.

Other Possible Interventions

The following are other possible interventions that could contribute to Feed the Future goals: the development of micro-irrigation systems; literacy training in marketing and trading; payments for ecosystem services; the use of grain reserves; establishment of systematic rapid response programs; crop insurance; improving accessibility to communication devices; the development of rural banking systems; rural infrastructure programs; programs to promote reliable regulatory enforcement and policies which create an enabling environment for equitable agricultural transformation.

Conclusion

It is often easier to use the agricultural systems that we are familiar with and that are supported by existing research and existing industries rather than search for the necessary solutions. When these systems do not take into account the differences of the agro-ecological zones, cultures and resource limitations, they are likely to fail in a majority of the areas where they are applied.

Underdeveloped farmers should not be trained to farm like well-developed farmers; there are many steps that need to occur in between in order to achieve a lasting foundation. These steps cannot be skipped. However, since this type of development requires a new paradigm, it needs leadership. USAID is in a position to provide that leadership.

It must include an understanding of the need for integrated soil management and a strategy that includes the entire ecosystem. This is critical throughout Africa due to the extensive degradation of soils.

Without a strategy that works from the bottom up, starting with soil health, improved seeds and building local capacity and institutions, no approach can succeed. It must be accepted that interventions for small-scale farmers in under resourced environments cannot be treated in the same manner as farmers and countries that are better developed. If we continue to do this, we will waste the new wave of commitments that could make the most significant advances in ending hunger that I have witnessed in my lifetime.

As evidenced in this photograph, the hillsides of many African countries are not conducive to mechanized agriculture. Therefore, these farmers need alternatives. Little research or time has been dedicated to developing these alternatives—or, how to bring them to scale. The combination of low levels of knowledge, soil degradation, steep slopes and varying agro-ecological zones present challenges farmers are not confronted with in North America or Europe. The largest hurdle to practical solutions for poor African farmers is the existing mindset driven by Western thinking. (Uganda)

A DISCUSSION ABOUT SMALL-SCALE AGRICULTURE

Historical Context

The United States began the development of its current agricultural system in the late 1700s. The most significant aspect was the establishment of a land tenure system. But it also included strong political *will* to support agricultural growth from the U.S. government, reflected in actions such as President Washington writing farmers in 1791 requesting information on land values, crops, etc.—essentially creating the first agricultural survey. Land ownership was the foundation of early success by providing farmers the opportunity to use land as a mechanism to borrow money, create equity and invest in improving production capacity. Generally, over a period of 100 years (1800-1900) the development of rail systems, roads, rural electrification and research created an environment that encouraged innovation and investment. During the second 100 years (1900-2000) of agricultural development in the United States, the United States Congress passed over 70 major federal acts which benefited production agriculture. The general level of education, the use of a common language and the systematic and consistent investment in public institutions were also underlying contributions to success.

In the late 1700s, 90 percent of the U.S. population depended directly on agriculture for their livelihoods (similar to many African nations that currently average over 70 percent). Research to improve farm productivity began as early as 1830. In 1839, Congress voted to fund the first agricultural census. In 1862, the United States Department of Agriculture was established and the Morrill Land Grant Act created agricultural colleges. In 1863, USDA's division of statistics was established creating monthly crop reports, and in 1887, the Hatch Act was enacted to fund agricultural experiment stations. The Smith-Lever Cooperative Extension Act of 1914 founded the heart of the current Farm Service Agency. This work done in the first 100 years set the stage for the next 100 years.

By 1950, the work horse had virtually disappeared from U.S. farms and almost 3.4 million tractors were in use, 25.8 million acres were under irrigation and single-row planters were replaced with six-row drills. The Agricultural Trade and Development and Assistance Act (PL 480) was enacted in 1954, Congress appropriated funds for the National Seed Storage Laboratory in 1956 and the Soil Bank program was implemented in 1957. In 1960, nitrogen use in the United States reached 2.7 million tons, 97 percent of farms had electricity and a pilot food stamp program was initiated. In 1965, over 95 percent of United States corn acreage was planted with hybrid seeds. Over 150 years of investment had established a firm base to expand agriculture into a dynamic and significant industry almost tripling production output over the following four decades.

Today, agricultural production in the United States is based on an integrated system of high-yield output that utilizes extensive mechanization, high levels of inputs and benefits from years of public and private research and development aimed at intensive monoculture production. It relies on transportation, infrastructure and storage systems developed at the commercial level as well as the farm level. A series of networks, including fuel, fertilizer, seeds, parts, technical support, machinery, financial services and other well-developed businesses, enable one farmer in the United States to produce enough food on average to feed 144 people a year. This is in contrast to poor farmers with little access to inputs, no training and limited infrastructure with minimal government support.

The most successful system for poor, small-scale farmers is likely a system that is designed on low-input and medium-output, or medium-input and medium-output. It should not mirror our system; however, it must use the same building blocks and investment to build the proper foundation.

Brazil is an example of how a country can accelerate this process, but it still depends on the basic building blocks.

In the Cerrado, several factors were critical in the advancement of the current agricultural system: the establishment and success of the "Brazilian Agricultural Research Corporation (EMBRAPA); publicly financed infrastructure, rural credit and business development services; the entrepreneurial know-how of highly skilled farmers from the southern part of the country who migrated to the Cerrado in response to the government's colonization strategy; and a supportive policy environment, brought about by a series of economic and political reforms enacted during the mid-1990s that improved the investment climate and permitted the direct transmission of international market signals to farmers in the Cerrado."[36]

Brazil had a number of other advantages including well-established credit systems, excellent infrastructure, proximity to successful agricultural systems, elevated interest from the private sector and strong government support. It is also a system based more on the industrial mode; however, it demonstrates the key ingredients for success—very similar to the U.S. model. Many of these elements are required regardless of the size of the farm operation.

Large mechanical production systems will not work well in many areas of Africa. The dynamics and the available resources of African farmers are considerably diverse. To understand the appropriate application of agricultural processes, it is necessary to draw clear distinctions between the physical, cultural and economic environments in which farmers operate. It is also critical to identify the greatest needs of farmers in different situations. A commercial farmer (elite), a smallholder farmer with access to local markets (stable) and a subsistence farmer (fragile) requiring a risk-averse livelihood strategy all have different profiles and require different solutions (see pages 16 - 18).

Characteristics of African Farmer Profiles[37]

FRAGILE

- Spends highest percent of income on food out of all groups
- Most likely to say off farm labor is most important source of income
- Consume some or all of primary crop
- Do NOT own an animal for plowing
- More likely to plow by hand or by renting an animal
- No mechanization
- Low or no use of inorganic inputs (fertilizer/pesticides/herbicides)
- Re-use seeds or get seeds for free
- More likely to have borrowed money in the last 12 months
- Higher percentage of households living on less than $2 per person per day
- Low maize yields
- Higher post-harvest losses
- No separate building for storage
- Sell none or some of most important crop
- Have almost no animals (except chickens)
- Typically consume 2 or fewer meals a day
- Less likely to consume meat/poultry/fish or dairy
- Highest number of children under 5
- Lower number of years of school
- Lowest conservation agriculture knowledge and practice
- Lowest crop acreage and total land
- More likely to be injured on farm
- More likely to have had a death in the household in the last 12 months
- Farmer more likely to be female
- Highest number of school-aged children not in school due to labor needs on farm
- Least likely to have electricity/generator
- Most likely to have gone without water
- Unlikely to have a bank account (unless they receive remittances)
- Lowest ranking on wellbeing scores
- Least likely to have visited a doctor or health clinic in the past year
- Closest doctor furthest away out of all of the groups
- Most likely to have children with persistent diarrhea in the past 12 months
- Most likely to have done work outside of the farm in the last 30 days
- Least likely to say they can always rely on income from selling crops
- Most likely to say finding it difficult or very difficult on present income

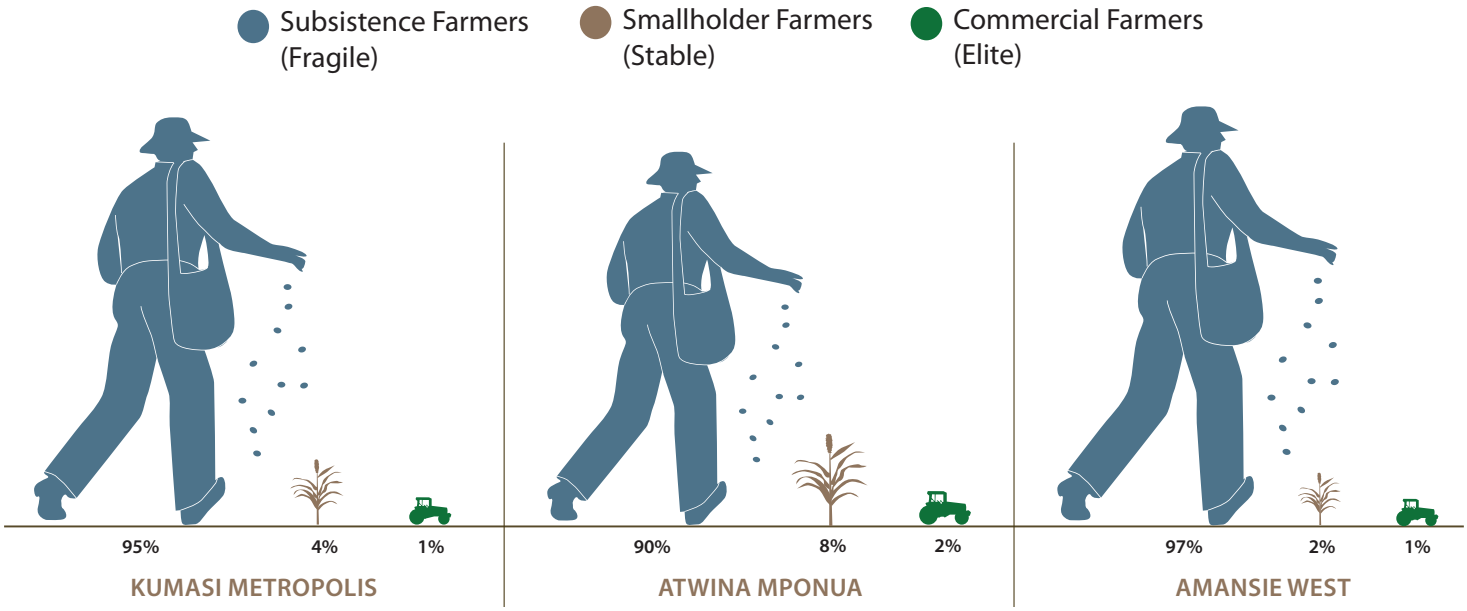
STABLE

- Consumed some or most of primary important crop
- Most likely to say crop sale is most important source of income
- Likely to own animal used for plowing
- Use a combination of purchased and own seeds
- Percent of income spent on food is between fragile and elite groups
- Mid but not high maize yields
- Some access to storage
- Some post-harvest loss (but less than fragile group)
- Sell some of most important crop but not all
- Have some livestock and more chickens than fragile group
- More likely to have sold livestock or animal production in the last 12 months than the fragile group
- Typically consume 2 to 3 meals per day
- Percent who consumed meat/fish/poultry and dairy in between fragile and elite groups
- Higher conservation agriculture knowedge and practice
- If school aged children not in school, most likely to be because cannot afford it
- Most likely to have visited a doctor or health clinic in the past year
- Likely to have done work outside of the farm in the last 30 days
- Likely to say they can always rely on income from selling crops
- Most likely to say they are getting by on present income

ELITE

- Use mechanization
- More than 20 hectares of crops and/or significant livestock holdings
- Cash crop is the most important crop
- High income (i.e. more than $10,000)
- No households living on less than $2 per person per day
- High input use—inorganic fertilizer, pesticides and herbicides
- Use of hybrid or improved seeds (and do not reuse seeds)
- Highest expenditure on inputs
- Use of irrigation
- Highest maize yields
- More likely to have had soil tests
- Own storage building or warehouse
- Low post-harvest losses
- Less likely to have problems from thieves in fields
- Consume little or none of their most important crop
- Sell most of all of their most important crop at strategic times
- Typically consume 3 or more meals per day
- Most likely to eat meat, fish, poultry or dairy on a regular basis
- Highest knowledge of conservation agriculture
- Higher education level
- Highest crop acreage and total land
- Highest TV ownership and access to Internet
- Most likely to be male
- Highest number of children in school
- More likely to use Internet for prices
- More likely to have electricity/generator
- Likely to have a bank account
- If borrowed money, will have borrowed from a formal institution
- Highest ranking on wellbeing scores
- Least likely to have done work outside of the farm in the last 30 days
- Most likely to report they can always rely on selling crops for income
- Most likely to say living comfortable on present income

DISTRIBUTION OF SIZE OF HOLDINGS IN ASHANTI REGION OF GHANA[38]



Subsistence Farmers with Limited Access to Local Markets (Fragile) < 2 ha (5 ac)

Uses family labor. Produces mainly for home consumption but sells a small amount at harvest for off-farm items such as salt, meat and other essentials. Immediately following harvest is normally a time when food prices are at their lowest so these farmers received reduced prices for their crop. They have no access to external production inputs such as fertilizer, herbicides and pesticides, or to organized markets. They will use their own saved seeds from previous harvests for the next crop. They have no storage facilities and their family experiences hunger gaps from one to three months, especially in the months of April, May, June and July. No irrigation facilities.

Smallholder Farmers with Limited Commercial Potential (Stable) 2 ha - 4 ha (5-10 ac)

Uses both family and hired labor, but primarily family labor. Uses some external inputs, mainly herbicides and improved seeds. Produces in excess of home consumption and will likely have some storage facilities. Sells a small amount of his/her crop at harvest as a necessity, but stores and sells the bulk later when prices improve. Does not experience hunger gaps under normal circumstances. No irrigation facilities.

Commercial Farmers (Elite) 4 ha (10 ac)

Uses mainly hired labor. Employs the use of external inputs such as improved seeds, herbicides, pesticides and inorganic fertilizers. This farmer has access to credit, typically stores the production from harvest and sells in the periods when prices increase. Has organized marketing (has buyers who come to buy or has the capacity to transport the produce to the buying center). Does not experience hunger gaps. Either owns machinery or has the capacity to hire machinery for required farm operations. Many have access to irrigation.

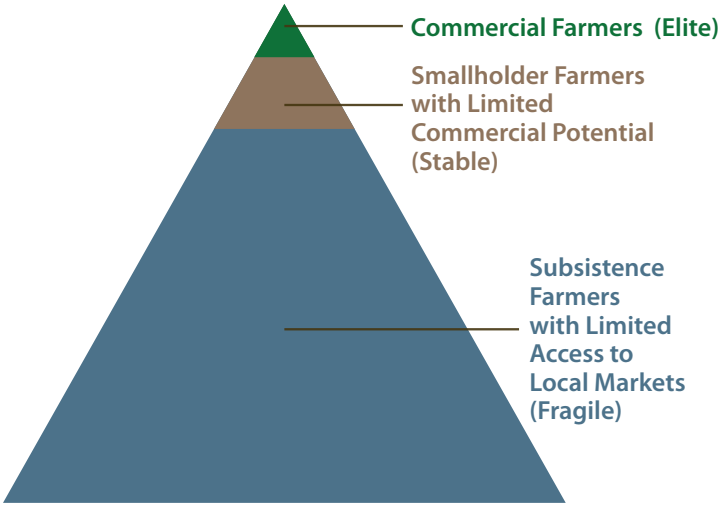
To develop appropriate solutions which address food insecurity, farmers' profiles must be defined and understood. Best practices for a farmer in the lower tier (below) will vary from those in the top tier. This can be a result of the type of crops, levels of soil fertility, use of mechanization, access to irrigation, the use of outside labor, applications of herbicides, use of improved seeds and pesticides or access to credit, among other factors.

A key distinguishing point is if a farmer is a net-buyer of food or a net-seller of food. A farmer who is a net-buyer of food depends on crop diversity for survival and produces primarily for home consumption; whereas a farmer who is a net-seller can afford to apply commercial techniques and use various sales strategies to maximize profit.

The productivity of these farmers is very different. The net-buyer will focus first on risk aversion; the other will determine crop production by market demand and is in a position to focus on yield improvements over maintaining crop diversity.

The top tier producer will have access to inputs, financing and a broader knowledge base of agronomic options. His or her situation may allow for timing of sales to take advantage of stronger market prices—whereas the lower tier group must sell a portion of his/her production immediately following harvest to meet family needs; crop sales are typically the only source of income for this group.

In stressful situations, the top group is in a better position to survive and possibly even benefit from market demands and volatility. If necessary, the lower group will sell assets, typically livestock, to meet immediate needs; this leads to rapid depletion of assets with little or no alternatives for recuperation, further deteriorating family health and well-being.



A CASE IN POINT

ETHIOPIA, JUNE 7, 2008

We meet with Adanech Seifa at the Misrak Budawacho distribution site in southern Ethiopia. This district has 56,000 people receiving food—another 66,000 are still in need of food aid. Adanech is at this site with her son who is severely malnourished. Her farm is less than .5 hectares (1.25 acres) and does not produce enough to feed her family. Her last two crops have failed due to drought, and she has no food storage. She sold her last goat and sheep to buy food. The value of the goat was 50 Birr ($3.94). This amount was not sufficient to feed her family for a week. A family food basket for a week made up of maize, false banana and flour costs 100 Birr ($7.88). Current food prices are high because food is scarce. At one time, Adanech had chickens that provided eggs; however, they died from either disease or drought—it is not clear. The drought and hunger have depleted all of her assets.

Systems and Farmer Profiles

Because subsistence farmers produce primarily for consumption and not markets, competitively driven markets can marginalize these farmers even further. This occurs because subsistence farmers typically sell a portion of their production following harvest at low prices to meet immediate needs, and later they purchase cereals and other products at higher prices when markets are no longer flooded with crops from the new harvest. Unlike countries where 10 to 20 percent of disposable income is spent on food, these populations can spend 100 percent of their resources on food and might still go hungry. Therefore, market development as we define it may not provide the positive dynamics we would expect.

This is a caution, not an argument against markets!

I began with a description of U.S. agricultural development not because other countries should adopt all of our specific development processes but to demonstrate that it took over 100 years of the proper investment and policy to create an environment that allowed accelerated growth for the next 100 years. In plain English, you cannot shortcut agricultural growth. The discussion today revolves too much around technology and monoculture-based systems and the concept that there are ways in which pieces of agricultural development can be skipped. There is no silver bullet—no technology can immediately fix 50 years of neglect. The basic foundation must be built over time, and the appropriate solutions must be identified. It is irresponsible to only promote solutions that fit *elite* farmers and expect *fragile* farmers to benefit. Without the proper investment and adequate time to develop a menu of solutions, an accelerated approach based on our current knowledge will largely fail for small-scale farmers in Africa.

These points were emphasized in a publication by the Food and Agriculture Organization (FAO) of the United Nations and The International Bank for Reconstruction and Development / The World Bank in 2009. The following excerpt from this publication supports the aforementioned conclusions.

> "Based on a comprehensive review of the literature, as well as the value chain analysis presented in this report, there is little to suggest that the large-scale farming model is either necessary or even particularly promising for Africa. Although some advocates of large-scale agriculture have pointed to the settler farms of eastern and southern Africa as successful examples, closer examination reveals that in many cases these farms were created by expropriating land from indigenous populations and nurtured with a stream of preferential policies, subsidies, and supporting investments. More recent attempts to foster large-scale farming in Africa, including those pursued by the Commonwealth Development Corporation (CDC), were hardly more encouraging, except in some plantation crops. Background papers on commercial farming in Africa commissioned as part of the CCAA study turned up not a single case where large-scale farms, outside of the settler economies, have ever achieved competitiveness in the export of food crops.

The CCAA value chain analysis suggests that the case in favor of large-scale farming in Africa is strongest in the presence of three particular sets of circumstances:

- When economies of scale are present, as for example in the so-called plantation crops (for example, sugar, oil palm, tea, bananas, and many horticultural crops grown for export). After being harvested, these crops need to be processed very quickly and/or transferred to a cold-storage facility; otherwise, they experience rapid declines in quality and hence value. If the farm operations of planting and harvesting can be successfully coordinated with the off-farm operations of processing and shipping, the economies of scale associated with the processing and/or shipping of these crops are transmitted to the farm level.

- When Africa's producers must compete in overseas export markets that have very stringent quality requirements and demand backward traceability of output all the way to the farm level, and in which contract farming is not feasible (for example, because of poor enforcement of contracts).

- When relatively fertile land must be developed in very low population-density areas (which include vast tracts of Guinea Savannah land). Without a large agricultural population representing a potential labor force, expansion into these areas will necessarily require mechanization. Although mechanization of smallholder agriculture is possible through the use of draft animals for hired machinery services, even if these technologies can be made available, development of relatively unpopulated areas still may require significant in-migration from other areas of higher population density, to which there may be political obstacles. Under such conditions, large-scale mechanized farming may be the best model, even for the production of staple foods.

In all three of these cases where large-scale farming may be cost effective, allocation of extensive tracts to farming enterprises is likely to engender land-tenure problems. Because there are virtually no areas that are entirely unused and unclaimed, land-tenure problems will often post enormous challenges—challenges that may be as difficult to resolve as the political issues surrounding in-migration of farmers and agricultural workers from elsewhere.

Large-scale farming, in most cases, is unlikely to be the most appropriate avenue for the commercialization of African agriculture, but this does not mean there are no important investment opportunities waiting in the sector. For the foreseeable future, however, the main opportunities for private investors, domestic or foreign, will remain in seed development, input supply, marketing and processing. Over the longer term, attractive opportunities for large-scale farming could emerge in plantation crops, including sugarcane and oil palm, which are the most efficient sources of biofuels.

If the Brazilian model of large-scale farming appears to have severe limitations in Africa, what about the Thai model of small-scale farms? Is the smallholder-led commercialization strategy pioneered by Thailand appropriate for African countries? There is no doubt that smallholder agriculture can drive rapid agricultural growth and bring about poverty reduction on a massive scale; this has been aptly demonstrated by many Asian and also several African countries. The theoretical and empirical literature shows that increased incentives felt by family farmers to work hard and manage their enterprises efficiently are at the root of the productivity advantage of the family farm. The finding of the CCAA value chain analysis that family farms are often the lowest-cost producers for the six target commodities is consistent with previous studies. This is not to say, however, that smallholder producers are the most efficient producers of all commodities; as discussed earlier, economies of scale are found in the plantation crops and among highly perishable commodities that must be processed and/or shipped quickly.

Yet smallholder-led commercialization strategies can also have downsides. Even when the income earned by smallholder households increases with commercialization, the intra-household distribution of income may worsen. Case study evidence shows that the welfare of women and dependents within some households deteriorates when those households switch to producing exportable cash crops. The relationship between the commercialization of agriculture, intra-household income distribution and household nutrition is complex and varies widely, depending on underlying socioeconomic factors. When encouraging smallholder-led commercial agriculture, governments and donors, therefore, need to pay careful attention to how the key determinants of intra-household welfare express themselves in particular local settings."[39]

"There are good reasons to be optimistic about the prospects for commercial agriculture in the African Guinea Savannah, but it is important to be clear-eyed about the challenges that lie ahead. Although it would be easy to feel overwhelmed by the list of constraints facing African farmers, Brazil and Thailand provide important lessons about how these constraints can be overcome. Arguably the most important lesson of all relates to the role of the state. In Brazil and Thailand, successive governments played a vital role by establishing a conducive, enabling environment characterized by favorable macroeconomic policies, adequate infrastructure, a strong human capital base, competent government administration and political stability. This conducive, enabling environment was a critical factor that allowed the private sector to mobilize its creativity, drive and resources in ways that served broader social goals as well as private interests. Rather than relying solely on heavy state management and investment, central and local governments of Brazil and Thailand were able to engage effectively with private investors, farmers' organization, rural communities and civil society organizations.

One advantage that African policy makers have today is knowledge that there are multiple paths to agricultural commercialization as demonstrated by the Thai and Brazilian experiences. Modern commercial agriculture need not be synonymous with large, highly mechanized farms. Although the Thai and Brazilian experiences show that agricultural revolutions can be driven by smallholders or large-scale commercial farmers, the weight of the evidence suggests that the fruits of those revolutions are more widely shared when smallholders participate. Second-round employment and poverty-alleviation effects are likely to be much larger with the smallholder-led model because growth in smallholder income tends to generate more demand for locally produced nontradables. In the case of low-value staples, however, it is unlikely that land-constrained households farming 1 to 2 hectares or less will be able to earn sufficient enough income to elude poverty. The emerging pattern of commercial agriculture in the African Guinea Savannah therefore must provide diversification opportunities for producers of low-value staples.

Further grounds for encouragement come from the knowledge that if the development of smallholder-based commercial agriculture begins solidly, the process can be self-reinforcing. As the Thai experience illustrates, those who initially gain in the process (for example, commercial farmers, farmer organization and agribusiness firms) will be motivated to lobby for policies and investments that can sustain the commercialization process, while at the same time generating some of the needed financial resources.

As commercialization broadens and deepens, larger private sector actors will have increasing incentives to invest in infrastructure and supporting services for value-chain coordination, thereby reducing the burden on government while generating expanded off-farm employment. "At the same time, political leaders must continue to play an active role, providing the vision, strategy, consistent implementation and long-term commitment needed to make the promise of agricultural transformation a reality."[40]

Brazil and Thailand are more appropriate to use as development models than India, which is addressed in the next section. The underlying theme in the FAO/WB report that small-scale farmers are a critical component to achieving food security is consistent with the InterAcademy Council report, the International Assessment of Agricultural Knowledge, Science and Technology for Development report and findings of The Fourth United Nations Conference on Less Developed Countries.

Previous Assumptions

1. Improved seeds have been discussed as a significant factor in improving yields. There is no question that improved seeds must play a role in a successful strategy to improve output. However, depending solely on the development of improved seeds fails to recognize the difference in available labor, cultures and farmer priorities.

Corn varieties in the United States are being bred to contain more starch and less protein—this may make sense for industrial use, but not for human consumption. It is the exact opposite of the traits that would be most beneficial to small-scale farmers who primarily produce for consumption. Therefore, simply transferring seed technology from the large, multi-national seed suppliers who are developing traits designed for industrial use and driven by profit is not the best strategy. There is a greater need for the development of varieties designed for human consumption and other needs found in developing countries.

What might be more useful to a poor farmer is the development of hybrids that are weed tolerant, similar to drought or disease tolerance. Hybrids in developed countries are designed for systems that use herbicides and pesticides. In contrast, small-scale farmers could benefit from varieties that reduce labor by providing better yields under heavy weed infestation. There are existing trials that demonstrate this is possible; however, no major seed companies would direct resources to this type of tolerance because it would not return a profit. There is no use for such a variety in a country like the United States, so public institutions in the United States would not pursue a variety for weed tolerance, especially with the limited resources available today.

Furthermore, there are a number of indigenous crops in Africa that have been grown for the past 6,000 years that can provide part of the solution to food insecurity; yet they continue to be largely ignored by Western researchers.[41]

The U.S. National Research Council provides six reasons why these crops have received limited attention: 1) inferiority of displaced crops; 2) misclassification; 3) poor people's plants; 4) inferior yields; 5) unworthy foods and 6) cost effectiveness.[42]

Number four is particularly important; a crop with no baseline data and no significant research will almost certainly be misjudged. These crops do not attract attention because they are not suitable as cash crops and are not in demand to meet export markets.

In addition, these crops have traditionally been grown on marginal ground and are susceptible to poor management practices. Therefore, the potential for these crops is unknown. The fact is these crops have continued to provide grain for thousands of years under difficult production conditions. They should be part of the equation as seed and research are considered.

The idea that these indigenous crops have nothing to offer is arrogant. Using today's technology to get the most benefit from these crops could provide important results. Using these specific crops and increasing the potential for these crops does not need to preclude the use of crops we are familiar with and that also provide potential to these farmers.

2. Without land ownership, you cannot achieve successful agricultural development. Farmers will not invest in something they do not own. This affects production capacity and land use in significant ways. It even plays out in successful agricultural systems. For instance, in the United States, the process engaged by a farmer who owns his land will be very different than if he rents land. This affects soil fertility, water usage (if irrigated), the environment and farming techniques as well as productivity. Therefore, there must be a concerted effort to establish a system that recognizes land ownership, allows for the transfer of property and legal remedies to resolve land conflicts. I do not believe even marginal success can be achieved without addressing this issue.

The Food and Agriculture Organization of the United Nations and The International Bank for Reconstruction and Development / The World Bank report states that "in Thailand, land policies that facilitate land titling and provided tenure security for small-scale farmers, combined with a generally more smallholder-friendly policy environment, allowed small-scale farming to emerge as the dominant mode of production."[43] Considering the physical constraints that exist in Africa, enabling small farm operations to meet their own food security requirements and extend into the market place is the most appropriate approach. The report further states that "the land-tenure system and distribution of land holdings determine who benefits directly from increased primary production."[44]

Therefore, as land rights are addressed, it is important to ensure poor populations are equitably represented. A larger benefit will result from tens of millions of farmers receiving land tenure versus a few hundred or even a few thousand elites or agribusinesses who are clearly well positioned in the market/value chain.

3. Without public investment, it is very difficult to incentivize private investment. It was public research in crop breeding that led to private investment in the United States which ultimately advanced the U.S. to an entirely different level of crop yields. However, the necessary public investment and specific research on best practices and management for the circumstances which exist in much of Africa is very limited. For instance, the U.S. Research Council wrote: "Africa has more native cereals than any other continent. It has its own species of rice, as well as finger millet, fonio, pearl millet, sorghum, tef, guinea millet, and several dozen wild cereals."[45] Because researchers are not as familiar with these crops, they are often ignored while more attention is given to the growth of the world's major grains.[46] Left to private investment, the U.S. system would not have progressed as it did. The same is true for Africa. However, Africa must utilize its own unique resources such as the crop species listed above. Unfortunately, there is little incentive for private investment in these crops because they hold limited to no potential for profit.

4. Western or Asian-style monoculture farm systems will not be effective with small-scale farmers in Africa. Monoculture systems fail to meet the critical importance of crop diversity required by poor farmers. These farmers rely on crop diversity to avoid hunger periods. The "Green Revolution" is discussed as a solution to Africa's production deficits, but it is important to identify why high-production systems work well in some environments and not in others.

The goal of Green Revolution-style systems is to provide the highest output, typically in monoculture conditions; in contrast, small-scale farmers require stable yields while maintaining diversity.

Subsistence farmers use crop diversification to survive the pests, diseases, droughts and floods that frequent their production cycles. It is not unusual to find six to eight crops being produced simultaneously. This diversification is critical to these farmers for several reasons: it maximizes the use of space, utilizes different root zones, draws upon nutrient fixing intercropping, creates micro-ecological areas and helps mitigate risk from crop loss. When the maize crop fails due to drought, or sweet potatoes deteriorate because of the feathery mottle virus, the cassava may survive. The ground nuts could be lost to a fungus, and the rice may be damaged by the birds and rodents, but the cow peas might do well. Crop diversity represents life to a small-scale farmer.

Perhaps the most important distinctions between many developing countries and those which have successfully implemented high-yield production systems are significant differences in available resources such as land tenure laws, government spending, access to fertile land, capital structures, long-term research programs, extension services, irrigation and well-developed infrastructure.

Investments such as these allow for a high-input system driven by yield. However, achieving the highest yield is not necessarily a poor farmers' primary goal—general food security, labor requirements and market access are often higher priorities. Benefiting from increased yields also assumes there are functional markets and transportation if surplus crops are produced. These systems do not necessarily transfer, first because these systems are not practical, and second because the populations are significantly different.

These are poor people first. They are farmers by default. Poor farmers do not farm for profit; they farm for consumption. Therefore, uncertainty puts their families at greater risk of hunger and malnutrition. The adoption of technology by small-scale farmers must be driven by a reduction in risk as well as increased yields.

5. India is often used as an example for African agricultural development; however, it is a poor example to use. During the first three decades they were in use, India benefited from the Green Revolution-style systems based on intense monoculture production and extensive irrigation. Under these systems, production of grains more than doubled. As a result, India achieved a reasonable level of independence for the majority of its grain requirements. However, child malnutrition rates in India remain worse than in many African countries—averaging 42.5 percent in children under five.[47]

India now is also experiencing challenges with water depletion and the negative effects of over-fertilization. Therefore, simply increasing food production does not ensure improved nutrition, access or affordability of food or sustainable farming practices.

India is a single country, while Africa is a continent comprised of 54 countries. The comparison of the two and the generalizations which result lead to misconceptions about how agricultural lessons transfer (or not). There are many differences. For instance, 60 percent of production in India uses irrigation,[48] and 80 percent of the hybrid seeds used by farmers are provided by private seed companies.[49] In Africa, 5 percent of production is irrigated, few subsistence farmers use hybrid seeds and private seed companies in many African countries have limited capacity, if they exist at all.[50] India had better infrastructure in 1950 than Africa has today. And, in India, the government was a strong advocate for high input systems. In Africa (excluding South Africa), agricultural research comprises less than 1 percent and agriculture overall comprises only about 5 percent, on average, of national budgets[51]—and this is for a continent with 70 percent of the population living in rural areas![52]

Certified seed is critical to building a successful seed industry throughout Africa. It is not uncommon to find seed sold in tin cans or small unmarked bags. The farmer rarely has knowledge of where the seed originated. Certified seed must be kept segregated and the agronomic value must provide profitability to both farmers and seed distributors. However, when a farmer is not farming for profit, it means a system built on profitability does not work. This is when government support is required to build acceptance through public programs. NGOs cannot provide this intervention at scale—it must be driven by governments through the development of public capacity, research and extension. (United States)

6. Agriculture is sometimes treated as a science—it is not a science! It uses science, but production agriculture has hundreds of variables that constantly change within each year. The largest single variable, weather, is completely outside of a farmer's control. Therefore, the heavy reliance put on technology is dangerous. Here are four examples of technology failures:

- *There is an assumption that technology is easily adopted.* The simplest technology is seed in a bag that has beneficial traits designed to maximize yields. At our farm in South Africa, we had an individual with a background in farming and an agricultural degree. He was responsible for the production of maize on four center-pivot irrigated fields totaling approximately 240 acres. When I arrived in South Africa to pick corn, the fields were full of weeds and grass. In places where the weeds had been controlled, the average yield was about 200 bushels per acre. Where the weeds were exceptionally bad, the yields were less than 40 bushels per acre. I could not imagine what might explain this situation since this corn had the Round Up ready trait which provides an efficient and effective way to control weeds.

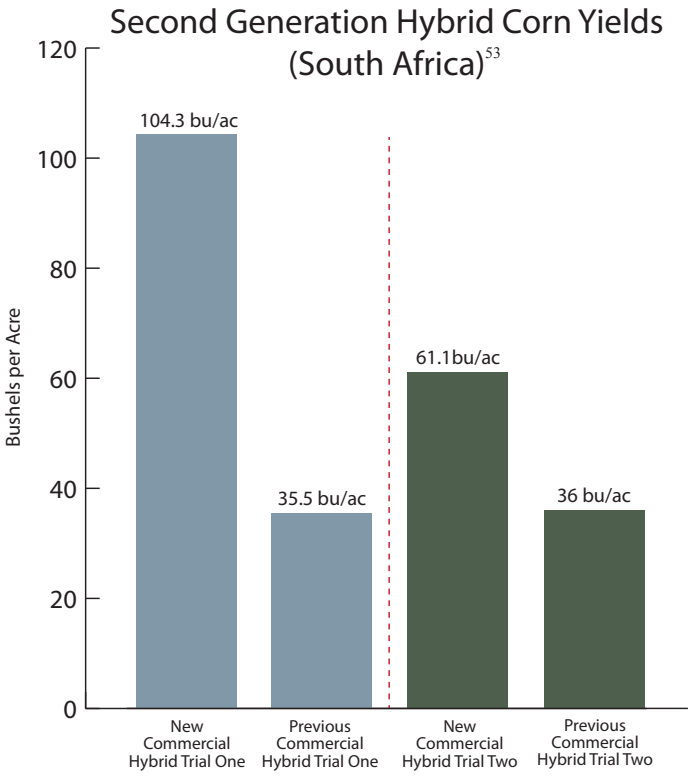
  This seed is very similar to what we use in the United States which delivers excellent weed control. Eventually, I discovered that the individual decided to let the weeds grow for an extended period of time so he could kill "all" the weeds. This allowed the weeds to exceed the growth stage for effective control. In addition to this, he assumed that Round Up would kill "everything," so he sprayed it once and used no residual herbicide. This is an educated man with experience, and he misused some of the simplest technology available. Imagine the idea of handing out improved seeds such as this to farmers who are not literate and have no training—the consequences could be life threatening.

- *Our experience with rice production led to similar experiences.* At the initiation of an experiment to determine water savings by producing rice under center-pivot irrigation, the farm manager in South Africa confirmed with the previous owner that the corn from the preceding crop year was not Round Up ready corn. After the rice was drilled and the rice emerged, the field had volunteer corn that rivaled the rice plants. The field was sprayed with Round Up and it had no effect on the corn. After we approached the previous owner two more times, he finally admitted that he had purchased corn in "unofficial" bags. In other words—"pirated corn." This provides two lessons: 1) farmers will use less expensive products if they feel they are adequate even without full knowledge of what they are using; 2) controlling the product is extremely difficult in environments where seed can easily be pirated. This will significantly undermine the seed industry and farmers' success and indicates that simply providing seed is not an adequate strategy.

- *In Liberia, I witnessed the results of using hybrid seed without the proper knowledge, training or soil fertility*. I visited a farmer who showed me an ear of corn that resembled one from my farm in Illinois. She explained that it was from the previous year. Then we walked to her field of maize. The current crop had experienced poor pollination and severe honeycomb. The ear fill was poor, ear size was small and erratic, and stalks had already begun to fail. She had planted a single-cross hybrid variety of corn developed for high-yield systems, and it led to an accelerated depletion of nutrients in the soil. (See chart below.) She replanted the hybrid a second year, and the combination of replanting the hybrid and the depletion of soil nutrients led to a crop failure.

  She was preparing to clear new land to compensate for lower yields and was in fear that her family would suffer from hunger as a result of her actions.

  If initial yields are favorable, a farmer may convert more land to hybrid corn, putting the family at greater risk if they experience a crop loss—primarily because they will sacrifice crop diversity to increase production of a single crop (corn). Resource-poor farmers may find that investments to improve production ultimately put them in an overcapitalized position, which makes their operation uneconomical, unsustainable or less productive.



Hybrid seed did well the first year it was planted. However, in the second year, the hybrid, which was designed for a high input system, depleted the nutrients in the soil and failed to produce an adequate crop. Contributing to the problem is the fact that hybrid seed is not designed for multiple year use. (Liberia)

In the example of the farmer in Liberia a farmer who adopts the use of a single-cross hybrid variety of corn must be able to afford to purchase new seeds each year, which is not the case with open-pollinated varieties or three-way cross hybrids. Countries like the United States have superior research, significant scientific capacity, strong commercially driven development of crop sciences and sizable financial investment (public and private) that provide options and a safety net not available to farmers in countries that do not have access to these resources.

It is important to recognize that crop varieties from high-input systems have higher impact on more fertile ground and less success in poor soils. Strategies such as high plant populations may work well where farmers can maximize production techniques and benefit from enhanced soil fertility programs, but they accelerate soil degradation when utilized in the wrong environment.

Included are production reports from our research farm in South Africa demonstrating the variance in yields between the first and second years of planting of hybrid seed. The reduction averages a loss of 46 percent the second year.

- *As new technology moves into agriculture, one of the fastest growing areas has been traits added to seed corn*. There tends to be several misconceptions of what these traits accomplish. Traits do not provide increased yields; the traits only help to insure the maximum yield potential is reached. The yield potential is determined by the hybrid. So if a seed variety has a BT trait, in some years this trait offers significant value when other years it may add little value—yet you pay for it either way. In other words, in a year with heavy infestation of corn bore, the BT trait is of significant value in controlling the corn bore. However, in years where there are no or only small amounts of corn bore, the trait is of little value. The trait acts more like insurance against loss. Our first year of research in Illinois demonstrates no yield advantage from the BT trait. Four years of experience on my personal farms have provided similar results. This is not conclusive, but it does demonstrate why we need to proceed cautiously.

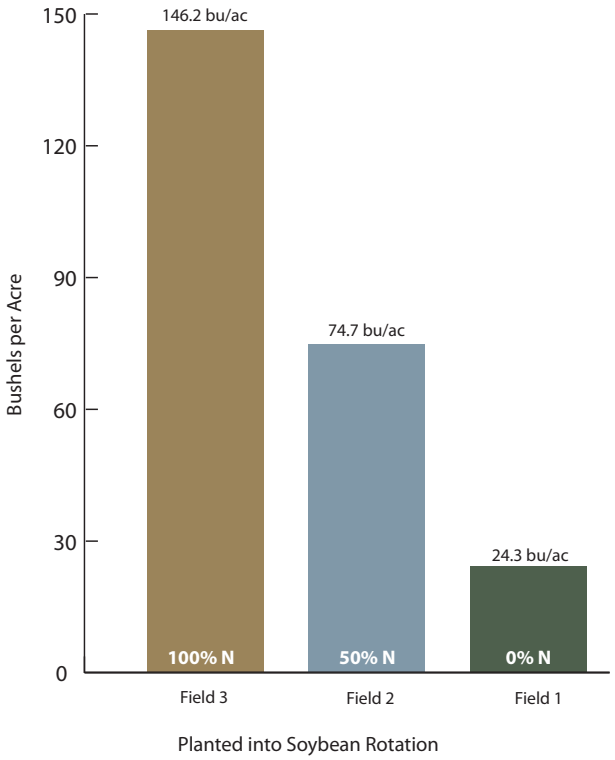
When drought-related traits are discussed, sometimes people state that a particular variety is drought resistant; this is not accurate. A variety can be drought tolerant, but the benefit can actually be difficult to define. It can mean that the yield is reduced by only 20 percent instead of by 50 percent because you used a variety with drought tolerance.

Different traits produce different results. In years with no drought, the trait will likely add little value. This raises the question: what can a farmer afford to invest in with respect to the benefit they might receive? In the growing year of 2010, I planted a variety that was promoted as "Smart Stack." It had eight traits; all were to provide additional yield protection. The cost was $340 per bag. A competitor's corn with two traits (RR and BT) costs $205 per bag and out-yielded the Smart Stack by an average of 20 bushels per acre.

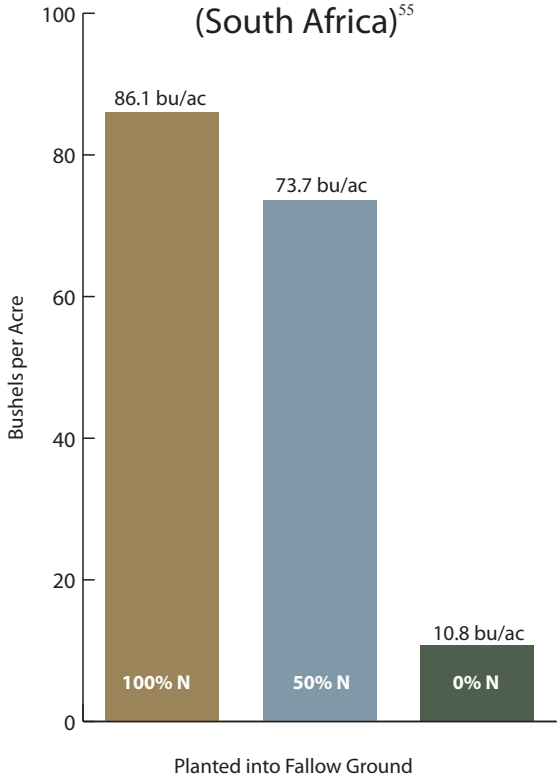
Another competitor's product which cost $240 per bag **without BT** out-yielded the Smart Stack by as much as 110 bushels per acre. Therefore, if poor farmers take the financial risk to make these investments, they put their livelihoods at stake.

In addition, there is much discussion that simply providing improved seeds can address production issues. The charts on the following page are examples of what occurs when hybrid seeds are used without a proper soil fertility program. Developing a soil fertility program requires a significant investment, but the use of improved seeds—particularly hybrids—requires such an investment.

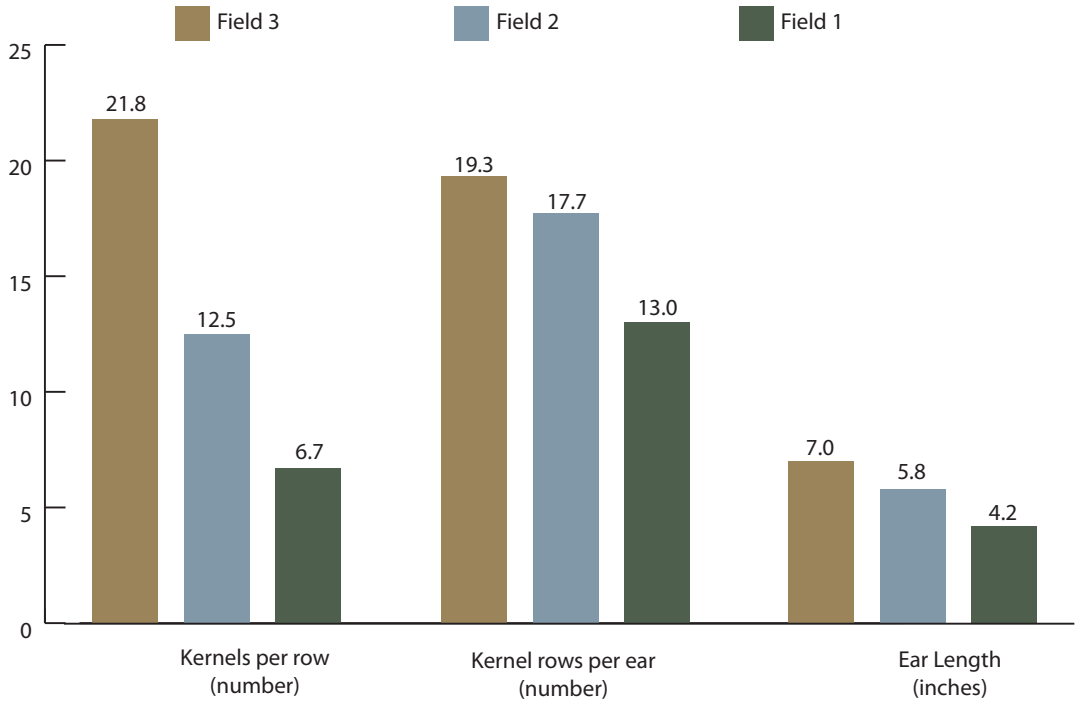
Nitrogen Deficiency Yields (United States)[54]



Nitrogen Deficiency Yields (South Africa)[55]



Nitrogen Deficiency-Corn Ear Development (United States)[56]



**Average corn population was 29,600*

7. Africa needs a *Brown Revolution*, not a *Green Revolution*. Africa has 220 percent greater population and 206 percent more land mass than the United States, and it has about 7.4 percent fertile soil across the entire continent.[57] However, the United States has about 30 percent fertile soil.[58] Africa has numerous agro-ecological zones, ranging from arid to tropical; the United States Corn Belt is primarily temperate. Therefore, production increases will need to come from a variety of approaches. Smallholder farmers who comprise 73 percent of the farmers in Africa and farm more than 70 percent of the arable land will need to be part of the equation to achieve food security across the continent.[59] Most of these farms are not suitable for Green Revolution-style development because they are small, fragmented, highly variable pieces of land with poor infrastructure.[60]

Three-quarters of potential agricultural land in Africa is subject to soil and terrain constraints, making large-scale mechanization difficult or uneconomical. Weathered soils in Africa have low inherent fertility and high fragility. Over half of the production zones in Africa have serious fertility problems, and 75 percent of agricultural soils in Africa have been significantly degraded by human activity.[61] Three quarters of Africa's farmland is severely depleted of the basic nutrients required for production of crops, compared with 40 percent only a decade ago.[62] In addition, African soils tend to be low in micronutrients which can constrain crop yields. Synthetic fertilizers cannot rebuild soil; rebuilding soil requires biological processes and specific farming techniques.

8. The assumption that appropriate inputs for poor farmers are similar to those used in countries with significantly higher GDP and income levels is incorrect. Making the poorest farmers reliant upon fossil fuels will worsen climate change and is likely to fail in many places where access, affordability and knowledge of how to utilize inputs are serious impediments. The consistency of supply and quality is also a serious problem.

9. Transfer of knowledge, particularly research, has had limited success in Africa. The area that has had some success is in crop breeding. However, most research has been directed toward rice, wheat, corn and soybeans in mono-cropping systems or for varieties that tend to work well in specific countries. There are clear exceptions to this statement; however, most research has been directed at where financial resources exist, and those resources are not available in remote places with poor, small-scale farmers. This is a primary reason why the majority of the discussion today revolves around pushing our system and knowledge into places where there is poor productivity rather than building systems that fit specific soils, growing conditions, infrastructure, etc. Very few new ideas have been considered because we tend to gravitate to what we know. Yes, it is easier and more convenient; however, convenience will not solve food insecurity.

As Daryll E. Ray, professor of agricultural economics at the University of Tennessee, points out, "What is lacking is research. The demand is so localized that major plant genomic companies cannot make any money on the small amount of seed they would sell if they researched the crop. And besides that, most of these crops are grown by subsistence farmers who have little cash with which to purchase seed. In addition, the support for public research has not been available despite the fact that most of these crops are represented by a large number of landraces, providing the genetic variability needed to establish a good breeding program. For example, while there are native varieties of African rice that are commonly grown, they are generally low-yielding—less than 1 tonne per hectare, compared to U.S. rice yields of 7 tonnes to 8 tonnes per hectare, there are landraces of Africa rice that yield 5 tonnes per hectare under African weather conditions. The problem is that these high-yielding landraces suffer from shatter and lodging. Both of these are problems that can be solved through traditional plant breeding techniques. What is needed is research."[63]

10. A significant challenge is the poor quality of data that exists for decision-making. I believe many of the decisions that are being made are done with incomplete, inaccurate or outdated material. It is difficult to get good soil profiles or hydrology information on our farms in South Africa, and South Africa is far ahead of many other African countries. Without understanding the problems, you cannot find the correct solutions.

11. Too often Africa is treated as a continent. Each of the 54 countries in Africa have unique and often very different sets of circumstances affecting its production capacity. Each intervention must be site specific, economic specific, culture specific, climate specific and country specific.

12. The lack of government *will* to make agriculture a priority creates a significant roadblock. We are all familiar with the low level of African budgets committed to agriculture. The threshold of 10 percent is still low and continues to be missed as a target by the majority of African countries. The assumption that this will somehow change is a big assumption, and success cannot be achieved without immediately changing this low level of commitment. The fact that the average length of service for an African Minister of Agriculture is 11 months also creates a challenge.[64]

The lack of continuity is a problem in fulfilling commitments and in developing the necessary relationships to encourage investment. These are systemic problems—they cannot be solved with money and they directly affect what can be done with production agriculture in a country.

These are some of the assumptions or structural impediments that I believe have caused us to fail in the past. To find some of the answers I would consider the evidence that was provided in three different reports, most of which has been ignored because it is not considered mainstream. To utilize this evidence requires an in-depth understanding of the circumstances in Africa, and it is often in direct conflict to the agenda of the existing industries.

Global Assessments

I will focus on three major groups of information in this section: the 2004 report by the InterAcademy Council commissioned by the United Nations under Kofi Anan; the 2009 International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) report which was originally initiated in 2002 by the World Bank and the Food and Agricultural Organization of the United Nations; and the recent Fourth United Nations Conference on Least Developed Countries.

InterAcademy Council Report

The key information retrieved from this report is the following statement: "The IAC panel concludes that African agriculture will require numerous 'rainbow evolutions' that differ both in nature and extent among many different types of farming systems and institutions throughout Africa—rather than a single Green Revolution."[65]

The findings that led to this conclusion include: a lack of dominant farming systems within Africa; a reliance on rain-fed production throughout Africa; a majority of the continent suffers from weathered soils of poor inherent fertility; key roles of woman are often not considered; there is a lack of functioning competitive markets; there is a serious lack of investment in agricultural research and development; a large diversity of farming systems exist; the importance of livestock must be considered; there is a lack of conducive economic and political environments; low and stagnant labor productivity exists; minimal mechanization is used and the predominance of customary land tenure.

The report also states:

> "In contrast to Asia—where irrigated rice-wheat systems predominate and thus where improved rice and wheat varieties could make a major difference—the diverse African situation implies that no single magic 'technological bullet' is available for radically improving African agriculture. A comprehensive set of strategies will thus be necessary in Africa for the effective harnessing of science and technology to meet human needs. As a consequence, more investment in a wider range of agricultural research and development will be required in Africa than was the case in Asia.
>
> African farmers pursue a wide range of farming systems that vary both across and within the major agro-ecological zones of Africa. Agro-ecological zones are land regions sharing similar combinations of soil, landform and climatic characteristics. The particular parameters used in the definition of these zones focus attention on the climatic and soil-related requirements of crops and on the management systems under which the crops are grown.
>
> A farming system is a population of crop and livestock enterprises that share similar patterns of farm activities and household livelihoods, including their degree of crop-livestock integration and their scale. Unlike other regions of the world where food production and food security are based primarily on a limited number of farming systems, in Africa these depend on multiple farming systems in a wide array of different agro-ecological zones. Diversity is the norm in African farming systems throughout the continent. At the level of the individual farm unit, farmers diversify further, typically growing 10 or more crops.
>
> Seventeen distinct farming systems are identified in Africa: maize-mixed, cereal/root crop mixed, root crop, agro-pastoral millet/sorghum, highland perennial, forest based, highland temperate mixed, pastoral, tree crop, commercial-large-holder and small-holder, coastal artisan fishing, irrigated, rice/tree crop, sparse agriculture (arid), urban based, highland mixed and rain-fed mixed. Most of these African farming systems are characterized by weathered soils of low inherent fertility and high fragility, by declining soil fertility due to population growth and a minimal use of external inputs, and by highly variable rainfall—especially in the drier rain-fed systems. For the foreseeable future, multiple farming systems must become more productive to generate the increases in food necessary to feed the hungry in Africa.
>
> The IAC panel concludes that, because of the many farming systems used to feed Africa, regionally mediated, rather than continent-wide strategies, will be required to address the diverse problems of African food productivity and food security."[66]

The Green Revolution approach worked because of uniformity; this conclusion identifies one of the primary reasons why the approach in Africa must be different.

The report provides the following recommendations:

- *"A strategy of integrated sustainable intensification.* The aim of science and technology should be to produce integrated soil, water, nutrient and pest management approaches that are effective for African farmers.
- *Reduce land degradation and replenish soil fertility.* Soil health and fertility management holds the key to enhancing crop productivity in Africa. An integrated approach that includes exploiting the effects of both inorganic and organic fertilizers on soil.
- *Bridge the genetic divide.* A substantial amount of additional investment is needed to respond to the specific needs of African farmers if they are to derive benefit from the integrated application of both conventional breeding techniques and biotechnology. Africa cannot rely on external developments in this field. Biotechnology has a significant gestation period before its impact is realized. Without substantial investments now, including by the private sector, Africa will be left behind. The full range of biotechnology components, including the appropriate use of genetically modified organisms, needs immediate attention to help improve eco-farming.

- *Improve the coping strategies of farmers in response to environmental variability and climate change.* Severe constraints in African agriculture include a high risk of crop failure and animal death because of the variability in weather, particularly rainfall. Climate change highlights the necessity to develop anticipatory short-and long-term forecasting research, and this requires the training of scientists.

- *Design and invest in national agricultural science systems that involve farmers in education, research and extension.* In place of the outmoded linear and top-down research-extension-farmer framework that has failed in Africa, design new innovation, information, knowledge and education systems—with new information and communications technologies playing a central role. Start from the bottom up in developing rural knowledge-based systems using participatory models.

- *Broaden and deepen political support for agricultural science.* Real improvement in agricultural education and research requires strong support from top political leaders. A coalition of supportive agricultural constituencies must be formed, including farmers associations, producer groups, national agribusiness companies, educators and researchers.

- *Strengthen science education at primary and secondary school levels.* A special emphasis must be placed on improving the accessibility and friendliness of science training to young women. Farm science schools where the pedagogic methodology is 'learning by doing' are urgently needed for the knowledge and skill empowerment of farmers.

- *Increase investments in rural infrastructure.* Governments must increase investments in roads, information and communications technology, storage and post-harvest technology and ensure that appropriate standards and regulations are in place and enforced.

- *Strengthen capacity and expand market opportunities.* Regional cooperation is required to remove formal and informal barriers to trade, strengthen the contract system, establish food quality and food safety standards and increase research capacity in all these areas.

- *Improve data generation and analysis related to agriculture, food and nutrition security and vulnerability.* Without good data, there are major constraints to the analysis of productivity trends and the design of appropriate strategies and policies for science and technology. The U.N. Food and Agriculture Organization, the World Health Organization and UNICEF should lead in this endeavor and design strategies to ensure that, in the future, the needed data are free of political influences."[67]

The purpose of providing these recommendations is to demonstrate consistency between the report and the recommendations I have provided at the end of this document.

The IAASTD Report

The IAASTD report involved 11 consultations involving over 800 participants. The concept behind this report was endorsed as a multi-thematic, multi-spatial, multi-temporal intergovernmental process with multi-stakeholders. The United States would not provide an unqualified endorsement of the report. In my opinion, it is the thinking behind this position that reflects why we have failed over the past 30 years.

In the 2008 World Development Report published by The World Bank, it states: "Structural adjustment in the 1980s dismantled the elaborate systems of public agencies that provided farmers with access to land, credit, insurance, inputs and cooperative organizations. The expectation was that removing the state would free the market for private actors to take over these functions—reducing their costs, improving their quality and eliminating their regressive bias. Too often, that didn't happen. In some places, the state's withdrawal was tentative at best, limiting the private entry. Elsewhere, the private sector emerged only slowly and partially—mainly serving commercial farmers but leaving many small-holders exposed to extensive market failures, high transaction costs and risks and service gaps. Incomplete markets and institutional gaps impose huge costs in forgone growth and welfare losses for small-holders, threatening their competitiveness and, in many cases, their survival."[68]

In my opinion, this reflects two things—an emphasis on trade and a dependence on private-sector engagement will result in continued failure. This is not an argument against either; it is an argument that trade will have little immediate positive impact on poor farmers and private investment will not occur or be successful without the proper foundation established by public investment and the correct public policy.

It must also be stated that what produces a profit for a company does not necessarily reflect the best management practices for a farmer.

The U.S. did not unequivocally accept this report because it did not endorse trade or the private sector strongly enough. If the U.S. government follows this same thinking with Feed the Future, a majority of the funds will have little chance of reaching the goals set out by Feed the Future.

The report provided the following conclusions:

- "Over the last 60 years, intensive production practices of high-yielding staple food crops were promoted, often on land cleared of much of its natural vegetation. To be productive for more than a few years, these crops require inputs of fertilizers, pesticides and often irrigation. In high-input agricultural systems, fertilizer and pesticide use is often excessive and environmentally damaging. In many parts of the world, small-scale farmers do not have sufficient access to state-of-the-art technologies, inputs, knowledge and innovations that enhance productivity while protecting health and the environment.

- Increased attention needs to be directed towards new and successful existing approaches to maintain and restore soil fertility and to maintain sustainable production through practices such as low-input resource-conserving technologies based on integrated management systems and an understanding of agroecology and soil science (e.g., agroforestry, conservation agriculture, organic agriculture and permaculture). These technologies minimize the need for high levels of inputs and are socially appropriate approaches to small-scale agriculture.

- An example of an integrated approach would be addressing the large difference between maize yield achieved by very poor farmers and the potential yield of the crop, mainly due to soil infertility and poor access to agricultural inputs through: 1) use of improved fallows to rehabilitate degraded farmland and increase maize yields 1-4 tonnes per hectare by using N-fixing legumes; 2) diversify into indigenous fruit/nut crops to generate income and to improve nutrition and health; additional income can be used to purchase fertilizers to give yield increases of 4-8 tonnes per hectare; and 3) process, add value and trade indigenous fruit/nut products to expand income and create employment.

- Organic agriculture (OA) includes both certified and uncertified production systems and encompasses practices that promote environmental quality and ecosystem functionality. Organic systems are knowledge intensive and based on replacing the use of synthetic inputs with ecologically based approaches to soil fertility and pest management. Benefits include lower levels of pesticides in food products and less pesticide and nutrient pollution in waterways and groundwater.

  The basic principle of OA is to enhance soil organic matter and soil structure through the supply of macro and micronutrients from animal and green manure (compost/mulch), nitrogen-fixing legumes, enhanced cation exchange capacity and nutrient retention.

  In 2006, organic production encompassed 31 million hectares, about 2 percent of cultivated land, on more than 600,000 farms in approximately 120 countries. With organic global sales now approaching US$40 billion, certified organic agriculture (COA) offers a challenging, but attractive rural development pathway for policy makers wishing to support the production of global public goods.

  OA can help expand a growing alternative global market that extends economic opportunity to small-scale producers and improves agricultural performance through better access to food and relevant technologies, as well as environmental quality and social equity.

- Reduced tillage and conservation agriculture (currently practiced on 5 percent of cultivated land, or approximately 95 million hectares) are economical systems that have been widely adopted in the last 25 years in North and South America, with current expansion in South Asia. Some of the benefits of conservation agriculture include reduced wind and water erosion, increased water use efficiency and water infiltration and enhanced conservation of soil organic matter. The resilience of conservation farming systems in the Central American highlands to recent El Nino droughts and to the catastrophic soil losses from Hurricane Mitch provide strong evidence of conservation agriculture's potential as an adaptative response to increased rainfall variability and storm intensity with climate change. Soil-specific research is needed to enhance applicability of no-till farming by alleviating biophysical, economic, social and cultural constraints.

- Agroforestry is a dynamic, ecologically based natural resource management system that through the integration of trees into agricultural landscapes diversifies and increases production, while simultaneously promoting social, economic and environmental benefits for land users—this approach is very similar to the concept of multifunctional agriculture."[69]

Perhaps one of the most important comments from the paper is found under the heading "Challenges." It summarizes the four critical elements to achieving success. It states: "Current assessments indicate that new research investments could improve multifunctional performance significantly and rapidly in all parts of the world. This requires that: 1) existing systems of multifunctional merit be up scaled and their underlying principles brought into mainstream practice; 2) empirically tested designs for new approaches and systems be more widely promoted in small-scale and industrial systems; 3) data and information be available in key areas of concern; and 4) policies and institutions that facilitate multifunctional agriculture be strengthened."[70]

Fourth United Nations Conference on Least Developed Countries

The conclusions of this conference were consistent with the identification of poor soil fertility issues and diverse growing conditions found in the IAC report; it is consistent with the IAASTD report where it identifies the need to build a biologically based system using low-input resource conservation-based approaches. The conference conclusions state that the transformation required in Africa should not be based on expensive imported external inputs.

Further, if the changes were based on the high-input, intense production model of industrial agriculture, it would put Least Developed Countries (LDCs) in a situation of "extreme vulnerability."[71]

The following are highlights from the report:

- "LDCs are primarily agricultural economies with nearly 70 percent of the population engaged in agriculture.

- Agricultural productivity in LDCs is relatively low. Land degradation is a major problem, due to increasing population pressure, erosion, water scarcity and the breakdown of traditional systems for soil fertility.

- The food import bill of LDCs rose from $9 billion in 2002 to $24 billion in 2008 (a decrease in agricultural productivity contributed significantly to this change).
- On-site processing of agricultural products is limited by energy poverty; 92 percent of rural households in sub-Saharan Africa have no electricity.
- Natural ecosystems provide most of the world's poor with food, fuel, medicine, building materials and cultural identity.
- Unsustainable land management practices lead to scarcity of water for both drinking and agriculture.
- The revolution in LDCs should not be based on expensive, imported external inputs. This demands that governments spend large amounts of their foreign currency reserves on agrochemicals (synthetic fertilizers, pesticides, herbicides, fungicides).
- LDCs import over 90 percent of the agrochemicals used in agriculture.
- It is problematic that the global seed, agrochemical and biotechnology market is dominated by few companies, with the four biggest controlling 60 percent of global agrochemical, a third of seed and almost 40 percent of biotechnology supply.
- There is a way that builds upon and gives value to LDCs' strengths: sustainable agriculture. It focuses on ecological and not chemical intensification of agricultural production. Sustainable agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects.
- Sustainable agriculture practices include composting, mulching, cover crops, crop rotations, inter-cropping, agroforestry, biological pest control measures, green manures, nutrient recycling, integrating livestock into farming systems, preventing erosion and water harvesting.
- A UNEP-UNCTAD analysis of 114 cases in Africa revealed that a shift towards organic agriculture production increased yields by 116 percent. Moreover the positive impact endures as it is based on strengthening the five types of capital in farming communities—human, social, natural, financial and physical.
- The regional government in Tigray, Ethiopia, provides extension services in sustainable agriculture techniques, particularly composting, prevention of soil erosion and water harvesting and has seen crop yields double and agrochemical use decrease by 95 percent.
- There is an urgent need for a fundamental shift in national and donor policies. Funds for agriculture should increase manifold. For poverty alleviation, and thus food security, GDP growth in agriculture has at least double the effect as growth in other sectors. How these funds are spent is even more important. The focus should be on:
    - Supporting small-scale farmers (the main source of food for the world's hungry) to improve their incomes, food security and access to markets, including local markets.
    - Increasing production of staple, non-traded, traditional and indigenous crops and livestock for local, domestic and regional markets. This provides varied nutritious food for local populations and protection from volatility caused by financialization and speculation in internationally traded agricultural commodities.
    - Promoting the development of sustainable agriculture systems, both production and markets."[72]

I disagree with the emphasis on organic agriculture as a system that provides health benefits; however, the fundamental attributes of the process as a production system are critical to success in Africa. Therefore, I reference the system as a biologically based production system.

Solutions

The following solutions are all consistent with the two reports and one conference referenced in the previous section. Some of these solutions are very basic and are accepted by many stakeholders. Others are geographically specific which will reflect different ideas and approaches than what some would commonly prescribe.

I begin this section with a quote from the United States National Research Council on lost crops in Africa. It states: "After the Year 2000, it could well be advances in today's 'second tier' cereals that are the buffers against famine. It is they that have the greatest amount of untapped potential…they are the crops of the poorest countries, which means their improvement could directly benefit the people in the greatest need."[73]

Soil Fertility

Improved soil fertility is critical. Existing NPK fertilizers provide crops with water-soluble forms of inorganic chemicals that will provide increased yields on "working soils." However, they provide little to no value to building soil fertility and will have limited to no success on "dead soil." Therefore, strategies must include biologically based systems to rebuild soil fertility.

This is more important today because there is less opportunity to leave land fallow. Populations and space pressures are forcing farmers to use land more intensely and to continue to clear land for new crop acreage. Therefore, universities, agricultural ministries, NGOs and other entities that are capable of providing extension services need to provide greater training in biological production systems.

Feed the Future could be the leader in encouraging a system that addresses the physical shortcomings of the African continent by developing a biological approach to African agriculture on scale. Endorsing such an approach would begin the "Brown Revolution" which Africa must experience.

Second Tier Crops

Feed the Future could support pilot research programs of "second tier" cereal crops, leading to increased yields from these indigenous sources. These crops have never received the level of support or research provided to the basic cash crops that are driven by profit and export markets. USAID could encourage research into these crops and jumpstart this process.

Improved Seeds

It is not possible to achieve the necessary yields to address food insecurity without improved seeds. Therefore, taking into consideration accessibility, affordability and knowledge, open pollinated varieties (OPV) should continue to be considered as viable options. However, where hybrid varieties can be combined with the proper fertility, more progress will be achieved.

As farmers progress, they are able to make different choices. By leaving OPVs out of the equation, it creates a much larger hurdle for poor farmers. Maximum yield is not always the ultimate goal of a poor farmer; therefore, the solutions for these farmers should not be driven by societies that have different goals; e.g., the goal of large seed companies and farmers in developed farming systems is yield—different goals require different solutions.

USAID could provide balance to the debate on improved seeds by supporting different levels of seeds for the appropriate level of farmers. Simultaneously, USAID should continue to support the development of a strong seed sector using the best technology where appropriate.

Extension and Farmer Field Schools

Extension services are at the heart of the success of United States agriculture. We need to take a trip back in time to understand what this means in Africa. African yields today are similar to the yields in the United States around 1900. The following table puts into perspective the current capacity in Africa; keep in mind Africa is 206 percent greater in land mass than the United States.

In certain circumstances, yields can be increased by the most basic education. As we strive to achieve uniform emergence in the United States using well-developed machinery, many African farmers plant by hand. U.S. farmers spend a significant amount of money to eliminate skips and doubles in their planting; farmers in other parts of the world purposely plant two to four seeds per hole. This is, of course, driven by the concern for adequate germination; however, it has a negative effect on yield. Therefore, training in proper row spacing, accurate seed depth placement, correct and consistent seed spacing, seed density, and timing of crop planting and harvesting offer as much potential as many other interventions.

Therefore, if Feed the Future develops a training program for existing African institutions based on basic agronomy techniques, it would address some of the easiest areas to correct. Currently many of the efforts today want to bypass the basics; therefore, these easy gains are overlooked.

Human and Institutional Capacity

The development of human and institutional capacity is often discussed, but historically funding has been limited. My experience is that private donors are slow to invest in African institutions, including my Foundation. Developing human and institutional capacity in Africa would require large amounts of funding and significant oversight in a system that often lacks integrity. It can take years to see the results. However, USAID could provide the proper resources to have a significant impact in this area. Without it, it is not likely that any successful, long-term, well-funded extension service will develop and be maintained.

Conservation Based Agriculture

A key component to success will be training and equipment that can take conservation-based agricultural production to scale. These techniques are particularly important in dealing with the effects of climate change. This is one area where knowledge transfer could be successful, but it would require intense training. Conservation-based agriculture also helps build soil fertility, contributes to better soil structure, conserves water, can help suppress weeds (requires the proper system) and acts as a carbon sink. It is particularly helpful in addressing gender issues because the system requires less labor.

USAID could demonstrate leadership by organizing farm equipment manufacturers and identifying equipment that could be tailored for small-scale farmers who are not subsistence farmers and who farm plots which can accommodate limited mechanization. U.S. manufacturers could provide "mechanization packages" at low levels of investment to promote the use of no-till and strip-till. This solution will not apply to all situations.

Post-Harvest Losses

The most immediate gains in reducing food insecurity could likely come from reductions in post-harvest losses. Since the labor and financial investment has already been made in the crop, these are extremely expensive losses. In turn, it is not difficult to see how reducing these losses could have the greatest return. Feed the Future could assemble a team of experts on crop storage and provide recommendations on what solutions work in different growing climates.

This team could provide information on approaches that have worked in various agro-ecological zones, how to bring them to scale, how to utilize ideas that work in other systems that transfer and suggest how funding should be applied. This will require small infrastructure development at a very local level.

Farmer Cooperatives

My Foundation has seen a significant difference in our level of success in Latin America based on the use of formal farmer co-operative (co-ops). The advantages consist of a more efficient use of resources, more effective communications, better purchasing power and the establishment of a political base. It is a much more effective way to provide training. We have found that the process of gathering individual farmers together is not the same as the dynamics that result from a co-op. Using a village approach does not provide the same advantages. This is a lesson we have learned over the past decade.

Feed the Future could develop a best practice model for the establishment of co-ops and provide incentives for farmers and governments to develop co-ops. It may require legal assistance, modifications to country laws or advocacy at the government level—all of which USAID could offer.

Better Leverage Existing Partnerships

Many interventions fail because they do not provide adequate exit strategies. An excellent example of a partnership that can be further leveraged is with the World Food Program (WFP). WFP's Purchase for Progress (P4P) program was initiated at the procurement level. This is the demand side, but ultimately it will be the supply side that determines the success of the P4P concept and the impact it can have on poor farmers.

Other Possible Interventions

The following are other possible interventions that could contribute to Feed the Future goals: the development of micro-irrigation systems; literacy training in marketing and trading; payments for ecosystem services; the use of grain reserves; establishment of systematic rapid response programs; crop insurance; improving accessibility to communication devices; the development of rural banking systems; rural infrastructure programs; programs to promote reliable regulatory enforcement and policies which create an enabling environment for equitable agricultural transformation.

Conclusion

It is often easier to use the agricultural systems that we are familiar with and that are supported by existing research and existing industries rather than search for the necessary solutions. When these systems do not take into account the differences of the agro-ecological zones, cultures and resource limitations, they are likely to fail in a majority of the areas where they are applied.

Underdeveloped farmers should not be trained to farm like well-developed farmers; there are many steps that need to occur in between in order to achieve a lasting foundation. These steps cannot be skipped. However, since this type of development requires a new paradigm, it needs leadership. USAID is in a position to provide that leadership.

It must include an understanding of the need for integrated soil management and a strategy that includes the entire ecosystem. This is critical throughout Africa due to the extensive degradation of soils.

Without a strategy that works from the bottom up, starting with soil health, improved seeds and building local capacity and institutions, no approach can succeed. It must be accepted that interventions for small-scale farmers in under resourced environments cannot be treated in the same manner as farmers and countries that are better developed. If we continue to do this, we will waste the new wave of commitments that could make the most significant advances in ending hunger that I have witnessed in my lifetime.

HOWARD G. BUFFETT,
PRESIDENT OF THE HOWARD G. BUFFETT FOUNDATION

- Operates a 1,400 acre family farm in Central Illinois.
- Oversees 2,500 acres of research farms in Illinois owned and operated by the Howard G. Buffett Foundation (HGBF).
- Oversees 9,200 acres of research farms in South Africa owned by a South African Trust established by funds from HGBF and operated by HGBF.
- His Foundation has funded more than 100 agricultural grants in 35 countries.
- His Foundation is currently funding a comprehensive field-based agricultural research program in Ghana in partnership with the Borlaug Institute of Texas A&M.
- Previously served as Chairman and share-owner of The GSI Group, a global agricultural sales and distribution company engaged in grain and animal husbandry systems.
- Previously served on the boards of Archer Daniels Midland, ConAgra Foods, Coca-Cola Enterprises, and currently serves on the boards of The Coca-Cola Company, Berkshire Hathaway, Lindsay Corporation and Sloan Implement, all of which are engaged or affected by agriculture.
- Previously served as Chairman of the Nebraska Ethanol board.
- Previously served on two USTR Advisory committees.

Photo courtesy of Emilia Casella

Buffett has visited with small-scale farmers in 35 African countries. Here, he discusses grain quality with a representative from The World Food Programme. (Sudan)

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